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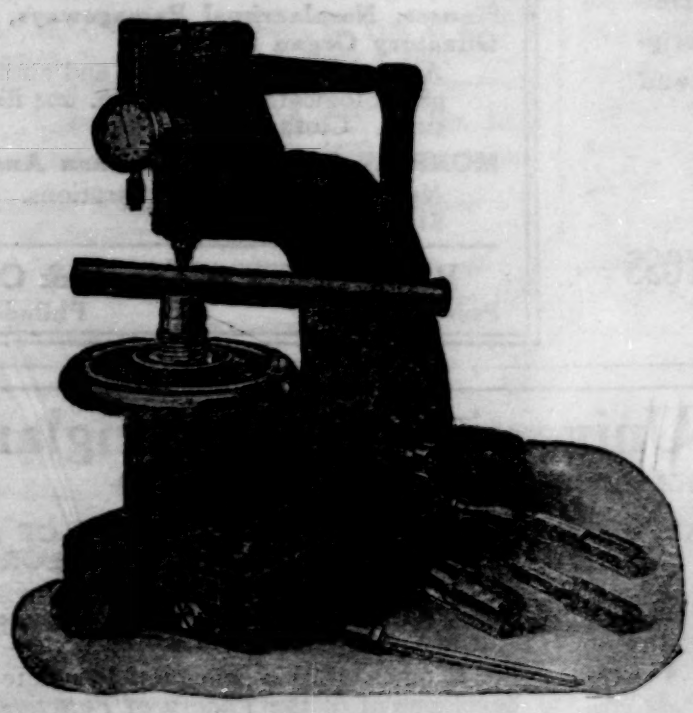

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A MECHANICAL ANALOGY IN THE THEORY OF EQUATIONS[1]

To the mathematician the solution of a problem is the more interesting if it utilizes methods and principles from fields that at first glance seem foreign to the one in which the problem lies. The question of whether a linear differential equation has algebraic solutions is sufficiently important to attract attention of itself, but its answer by reference to the properties of regular polyhedrons has become a mathematical classic. Such analogies are not, however, to be regarded as mere *tours de force* whose purpose is only to astonish, or to appeal to a certain esthetic sense; the instance just mentioned shows that the new point of view may disclose wide vistas hitherto undiscerned. If there is a choice of terms in which the analogy may be stated, the formulation which is most concrete and most striking may also be the most illuminating.

Such considerations as these, doubtless, have led to the description of what are essentially vector methods with complex variables in terms of mechanical systems. I propose here to discuss the progress that has been made by the aid of such an interpretation in studying the distribution in the complex plane of the roots of algebraic equations in one variable.

On the algebraic side the chief purpose of the investigations to be considered has been to obtain what may be called *theorems of separation, i. e.,* theorems which state whether roots of an equation do or do not lie in specified regions of the complex plane. Such theorems may also state how many roots lie in the specified regions, or may give limits, inferior or superior, for the number of roots thus situated. These regions may be defined in terms

[1] Address of the vice-president and chairman of Section A—Mathematics, American Association for the Advancement of Science, Toronto, 1921.

of the roots of other polynomials; we are then concerned with *relative distributions* of the roots of two or more polynomials.

Theorems of separation for real roots of real equations are numerous, and are among the most familiar results in elementary mathematics. I need only mention Descartes' rule, which gives a superior limit for the number of roots on the positive real axis, or Sturm's method for obtaining the exact number in any real interval. Rolle's theorem, in the form which states that between each consecutive pair of real roots of a real polynomial $f(x)$ there lies an odd number of real roots of the derived function $f'(x)$, is perhaps the most important proposition concerning relative distributions of real roots of two real polynomials.

No such progress has been made with similar propositions for complex roots, although the widening of the field of observation from the real axis to the complex plane vastly increases the range of possibilities. To be sure, we have extensions of Sturm's theorem, and other methods, both algebraic and transcendental, which give criteria for the exact number of roots within a region, but in practice these prove so cumbersome as to be of little use. The great desideratum is a body of results whose simplicity and range of applications would make them comparable with Rolle's theorem, or the Budan-Fourier theorem in the real case. As Jensen has remarked, the solution of important problems regarding the zeroes of transcendental functions may be dependent upon progress in this direction.

The significance of Rolle's theorem naturally led to attempts to extend it to the complex plane almost as soon as the now familiar geometric representation of complex numbers had been adopted. A line of attack is clearly indicated by the identity of the logarithmic derivative

$$\frac{f'(x)}{f(x)} = \frac{1}{x-a_1} + \frac{1}{x-a_2} + \ldots + \frac{1}{x-a_n},$$

where $f(x)$ is a polynomial of degree n, whose roots are $a_1, a_2, \ldots, a_n$, and $f'(x)$ is the first derivative of $f(x)$. Gauss was probably the first to give this a mechanical interpretation which depends on the representation of a complex number $x-a$ as a free vector whose length, $|x-a|$, and direction are those of the directed line segment from the point which corresponds to a, or, more briefly, from the point a, to the point x. The conjugate of the reciprocal of $x-a$, which may be denoted by the symbol $K\frac{1}{x-a}$, corresponds to a vector having the same direction as the vector $x-a$ but with a length equal to the reciprocal of $|x-a|$. This is precisely the vector which represents the force at x due to a particle of unit mass at a which repels with a force whose magnitude is equal to its mass divided by the distance. If, then, we take the conjugate of both sides of the identity of the logarithmic derivative, we have the theorem of Gauss: *The roots of* $f'(x)$ *which are not also roots of* $f(x)$ *are the points of equilibrium in the field of force due to particles of unit mass at the roots of* $f(x)$, *each of which exerts a repulsion equal to its mass divided by the distance.*

From this result it is but a step, though one not taken for many years, to the polygon theorem of Lucas, now sufficiently well known to have a place in Osgood's "Lehrbuch der Funktionentheorie," but discovered and rediscovered, proved and reproved in most of the languages of Europe—and all the proofs are substantially the same! This ignorance of the work of others characterizes even some of the most important contributions in this field. Lucas, for example, seems to have considered himself the discoverer of the theorem of Gauss, which really antedates his work by many years.

The polygon theorem, in its usual form, is a theorem of relative distribution which states that the roots of the derived function $f'(x)$ lie within or on the perimeter of the smallest convex polygon (or line segment) which includes within itself or on its boundary all the roots of $f(x)$. This statement implies that there is but one such polygon (or line segment), which reduces to a point if $f(x)$ has all its roots coincident. In case the polygon of Lucas does not reduce to a line or a point, the only roots of $f'(x)$ on its perimeter are multiple roots of $f(x)$. An equivalent form giving a separation theorem for the roots of $f(x)$ states that every straight line through a root of $f'(x)$ either passes through all the roots of

$f(x)$ or else separates them, *i. e.,* has roots on each side of it. This form is immediately suggested by the corresponding mechanical system; it is evident that a point of equilibrium must either be collinear with all the repelling particles, or else the latter must be seen under an angle of more than 180° from the former.

This result is only one of many concerning the relative distribution of roots of $f(x)$ and $f'(x)$ that may be inferred from the conditions of equilibrium of our mechanical system; we have deduced it by taking account only of the directions of the repelling forces. By considering their magnitudes as well J. Nagy (Jahresbericht der Deutschen Mathematiker Vereinigung, Vol. 27 (1918), page 44) has obtained a number of interesting theorems of which the following is one of the most striking: *If* α *is a root of the polynomial* $f(x)$ *of degree* n, *and* β *is a root of* $f'(x)$, *every circle through the points* β *and* $\gamma = \beta + (n-1)(\beta - \alpha)$ *contains at least one root of* $f(x)$. The proofs given do not, however, make explicit use of the mechanical analogy. In a paper read before the International Congress of Mathematicians at Strasbourg J. L. Walsh has utilized Gauss's theorem in discussing the case where the roots of $f(x)$ lie in two circles.

If the repelling particles exert a force inversely proportional to the square of the distance we obtain theorems of relative distribution of roots in which $f'(x)$ is replaced by $f(x)f''(x) - [f'(x)]^2$; from a root of the latter function the roots of $f(x)$ must be seen under an angle of at least 90°, and the polygon of Lucas is replaced by one bounded by arcs of circles. Other extensions of this sort suggest themselves, but nothing, so far as I am aware, has been published along this line.

An immediate corollary of the polygon theorem states that all the roots of all the derived functions lie within the polygon of Lucas. It is well known that the centroid of the roots of $f(x)$ coincides with that of the roots of its derivative of any order. An often discovered theorem places the roots of $f'(x)$ at the foci of a curve determined by the roots of $f(x)$.

In 1912 Jensen, in a very suggestive memoir on the theory of equations (Acta Mathematica, Vol. 36), stated without proof a theorem for equations all of whose coefficients are real which may be regarded as an improvement on the polygon theorem. If $f(x)$ is a real polynomial its complex roots form conjugate pairs. The resultant force of repulsion due to particles at such a pair of points is directed away from the real axis at a point not on this axis and which lies outside the circle whose diameter is the line segment joining the pair; we designate this circle the *Jensen circle* of the pair. At a point within the Jensen circle and not on the real axis the resultant force due to the pair is directed toward the real axis, while on the real axis and on the circumference of the circle it is parallel to the real axis. Thus at a point which is neither on the axis of reals nor within or on the circumference of any of the Jensen circles corresponding to the complex roots, the resultant force of repulsion due to the whole system of particles at the roots of $f(x)$ cannot vanish, for the force due to each particle on the real axis is directed away from that axis, and the same is true of the forces due to pairs of particles at the complex roots. We thus have Jensen's theorem: *The roots of* $f'(x)$ *which are not real must lie within or on the Jensen circles of* $f(x)$. To be more precise, a root of $f'(x)$ cannot lie on a Jensen circle unless it is real, or unless it is a multiple root of $f(x)$, or unless it is also within or on another Jensen circle.

Since the addition of a constant force parallel to the real axis does not change the above argument, Jensen's theorem remains valid when we substitute for $f'(x)$ the function $af(x) + f'(x)$ where a is any real number. Another extension indicated by Jensen concerns the regions within which roots of the successive derived equations lie, these regions being defined in terms of the roots of $f(x)$. Thus the complex roots of $f''(x)$ are in the Jensen circles of $f'(x)$, whose centers are on the axis of reals and whose vertical diameters are within the Jensen circles of $f(x)$. The solution of a simple problem in envelopes shows that all the complex roots of $f''(x)$ lie within or on ellipses each of which has a pair of complex roots of $f(x)$ at the ends of its minor axis and has a major axis whose length is $\sqrt{2}$ times that of its minor axis. For the

rth derived equation the result is the same except that the ratio of lengths of axes is $\sqrt{r}$. Jensen states that this is also true of the function $g(D) \cdot f(x)$, where $g(D)$ is a linear differential operator of order r with constant coefficients whose factors are all real, and that $f(x)$ may be an integral transcendental function of genus zero or one.

In a recent paper (Annals of Mathematics, Vol. 22 (1920) p. 128), J. L. Walsh notes some results for non-real polynomials which follow from considerations that led to Jensen's theorem. He also gives an answer to the question which at once suggests itself as to how many roots of $f'(x)$ lie within a Jensen circle when $f(x)$ is real by a method of interest in itself, doubtless suggested by Bôcher's treatment of a similar problem which we shall note later. By allowing all the roots of $f(x)$ outside a Jensen circle to move out to infinity, noting what roots of $f'(x)$ may enter or leave the circle, and counting those within the circle at the end of the process, Walsh concludes that *if a Jensen circle has on or within it* k *roots of* f(x) *and is not interior to nor has a point in common with any exterior Jensen circle, then it has on or within it not more than* $k+1$ *nor less than* $k-1$ *roots of* $f'(x)$. In a paper not yet published I have obtained a result a little more precise than this in which, for the sake of simpler statement, I will suppose neither $f(x)$ nor $f'(x)$ has multiple roots. By the term "root of even index" I designate a real root of $f'(x)$ between which and the next real root of $f(x)$ to the right or left there lies an odd number of real roots of $f'(x)$; if $f(x)$ has no real roots this term denotes every other real root of $f'(x)$, starting with the least. All the real roots of even index of $f'(x)$ can be shown to lie in or on Jensen circles, and every such circle that has no point in or on it within or on any other Jensen circle has within it either just one real root of even index of $f'(x)$, or just one pair of complex roots of $f'(x)$. The region covered by a system of Jensen circles each of which overlaps or touches some other of the system has within it the total number of real roots of even index and of pairs of complex roots of the derived equation which the circles would have if they were separated, but there may be circles of the system containing no such points. General criteria to determine whether even an isolated Jensen circle contains a pair of complex roots or a real root of even index of $f'(x)$ are lacking, though Walsh discusses special cases, in some of which we may use a circle smaller than Jensen's.

Relative distributions of the roots of a real polynomial $f(x)$ and of its derivative in various special cases have been discussed by H. B. Mitchell (Transactions of the American Mathematical Society, Vol. 19 (1918), p. 43). The identity of the logarithmic derivative is used, but the mechanical analogy and Jensen's theorem are not cited.

So far we have been concerned only with theorems of relative distribution for the roots of a polynomial and of its derivative. In a most suggestive paper by Bôcher ("A Problem in Statics and its Relation to Certain Algebraic Invariants," Proceedings of the American Academy of Arts and Sciences, Vol. 40 (1904), p. 469) our mechanical system is generalized by assigning to particles at points $e_1, e_2, \ldots e_n$ masses $m_1, m_2, \ldots m_n$ respectively, with the same law of repulsion as before. Negative values for the masses are admitted, the repulsion becoming an attraction in the case of the corresponding particles. The field of force is then given in both magnitude and direction by

$$K\left(\frac{m_1}{x-e_1}+\frac{m_2}{x-e_2}+\ldots\ldots+\frac{m_n}{x-e_n}\right).$$

The cases of greatest interest are those in which the sum of the masses is zero. By projecting such a system stereographically upon a sphere (the same result could be established by inversion on a circle about x), Bôcher proves that a point cannot be a position of equilibrium if it is possible to draw a circle through it upon which not all the particles lie and which completely separates the attractive particles which do not lie on it from the repulsive particles which do not lie on it.

A remarkable property of these systems whose total mass is zero is now developed by introducing homogeneous variables

$$x=\frac{x_1}{x_2},\ e_i=\frac{e'_i}{e''_i}$$

If the above expression for the field of force is reduced to a common denominator within the parenthesis, the numerator is the product of x_2^2 and *a covariant* ϕ *of weight* 1 *of the* n *linear forms* $e_i''x_1 - e_i'x_2$. The points of equilibrium are roots of the covariant ϕ, and ϕ vanishes at no other points unless two of the particles coincide. If the points e_i are defined as the roots of a system of binary forms f_r, the masses of all the particles corresponding to each f_r being equal, ϕ is an integral rational covariant of the forms f_r, and we are thus led to theorems of relative distribution for the roots of a system of forms and those of a covariant of the system. In particular, if the system consists of but two forms, the covariant ϕ is their Jacobian; in all cases ϕ can be expressed as a polynomial in the ground-forms and Jacobians of pairs of the ground-forms.

The conditions of equilibrium of the corresponding mechanical system can now be interpreted as theorems of separation for the roots of the forms. Thus if f_1 and f_2 are two binary forms whose roots are all in circles C_1 and C_2 respectively, and these circles do not touch or overlap, then all the roots of the Jacobian of f_1 and f_2 are in C_1 and C_2. The actual number of roots in each circle is obtained by allowing the roots of f_1 to coalesce at a point a_1 and shrinking C_1 to this point; during this process C_1 is always to include all the roots of f_1. At the end of this process the Jacobian has $p_1 - 1$ roots at a_1, where p_1 is the degree of f_1. We conclude that the Jacobian originally had this number of roots in C_1, and a correspondingly determined number in C_2. The circles C_1 and C_2 may be replaced by circle-arc polygons.

The polygon theorem of Lucas corresponds to the special case where one of the ground-forms reduces to x_2.

A case of especial interest is that where one of the two ground-forms is linear; we have just noted a particular instance. The Jacobian of $y_2x_1 - y_1x_2$ and $f(x_1, x_2)$ is the first polar of (y_1, y_2) with respect to f. In a series of papers dating from 1874, to be found in his collected works, Laguerre had developed separation theorems for a binary form and its polars, without the use of our mechanical analogy. Bôcher seems to have been unacquainted with these results, which, however, are directly obtainable from his own. If the circle C_1 of the preceding paragraph is replaced by the point (y_1, y_2), we have Laguerre's theorem which states that if this point is outside a circle C_2 that contains all the roots of $f(x_1, x_2)$, then all the roots of the polar $y_1f'_{x_1} + y_2f'_{x_2}$ lie within C_2. Laguerre gives this a more striking form by supposing (x_1, x_2) taken arbitrarily and determining the "derived point" (y_1, y_2) as the point which makes the polar vanish. *Every circle through a point and its derived point either has all the roots of* $f(x_1, x_2)$ *on it, or else there is at least one root within and at least one root without the circle.* In non-homogeneous variables the derived point y of a point x with respect to $f(x)$ *is*

$$y = x - n\frac{f(x)}{f'(x)},$$

where n is the degree of $f(x)$. The first approximation to a root of $f(x)$ being x, the next approximation by Newton's method is $x - \dfrac{f(x)}{f'(x)}$. Thus we have a most interesting light upon Newton's method in the complex plane; it replaces x by a point *within* a circle on which x lies, and which surely contains a root of $f(x)$.

A point coincides with its derived point when and only when the point is a root of $f(x)$. Let α be such a simple root, and let β be its derived point with respect to $F(x)$, where $f(x) = (x - \alpha)F(x)$, and the degree of $f(x)$ is at least two. Since $F(\alpha) = f'(\alpha)$, and $F'(\alpha) = \frac{1}{2}f''(\alpha)$, we have

$$\beta = \alpha - (n-1)\frac{F(\alpha)}{F'(\alpha)} = \alpha - 2(n-1)\frac{f'(\alpha)}{f''(\alpha)}.$$

Each circle through α and β either has all the roots of $f(x)$ upon it or else at least one is within it and at least one is without. There is thus at least one root whose distance from α is not greater than $2(n-1)\left|\dfrac{f'(\alpha)}{f''(\alpha)}\right|$.

Laguerre and others have made interesting applications of these results to polynomials

all of whose roots are real, and to polynomial solutions of linear differential equations.

Before leaving this phase of our subject we may note, with Laguerre, that similar theorems hold for each of the successive polars of a binary form with respect to a point. An interesting field hardly touched as yet is that of separation theorems for the successive polars of a form with respect to a sequence of points defined as the roots of another form. By taking the two forms in a special case where they are apolar Grace has proved (Proceedings of the Cambridge Philosophical Society, Vol. 11 (1901), p. 35) a result equivalent to this: *If the distance apart of two roots* α_1, α_2 *of a polynomial* $f(x)$ *of degree* n *is* 2a, *there is at least one root of* $f'(x)$ *on or in the circle whose radius is a cot* $\frac{\pi}{n}$, *and whose center is* $\frac{1}{2}(a_1 + a_2)$. In this paper lack of references indicates ignorance of Laguerre's work. The same result was proved later by Heawood (*Quarterly Journal of Mathematics*, Vol. 38 (1907), p. 84) by allowing all the other roots of $f(x)$ to vary suitably. Here, again, there is no reference to any other work in this field.

To return to more recent work on the vanishing of the Jacobian of two forms f_1 and f_2, we note two very interesting papers by Walsh in the Transactions of the American Mathematical Society, in which are discussed cases where the roots of the ground-forms are in three circles, instead of two. An added interest is shown to attach to the Jacobian because the numerator of the derivative of a rational function

$$\frac{u(x)}{v(x)} = \frac{f_1(x_1, x_2)}{f_2(x_1, x_2)}$$

is x_2^2 multiplied by the Jacobian of f_1 and f_2. Separation theorems for the Jacobian are then interpretable in terms of this derivative. The results of these papers are, of course, only a first step to the consideration of still more general separation theorems. The field is the more interesting in that its investigation involves a combination of mechanical, algebraical, and geometrical considerations.

I must close with only a mention of certain extensions of the problem we have so far considered. Thus Bôcher, generalizing a method due to Stieltjes, considers the positions of equilibrium of a system of free particles of equal mass in a field of force due not only to a number of fixed repelling particles, but also to their own mutual repulsions according to the same law. If the total mass of fixed and moving particles is 1, the positions of equilibrium of the free particles are determined by the vanishing of covariants, of which some examples are given by Bôcher. These results, as well as some obtained by adding a force function $K[f(x)]$, are useful in the study of polynomial solutions of differential equations. We must regret that Bôcher was never able to fulfill the hope twice expressed in this paper that he might be able to return in detail to these problems which he had merely sketched. Their investigation requires considerable skill, but, if successful, would add a new and important chapter to algebra, with a striking application of invariant theory.

D. R. CURTISS

NORTHWESTERN UNIVERSITY

WILLIAM BATESON ON DARWINISM

ASIDE from the fine impression created by the admirable series of papers and addresses in biology, zoology and genetics in Toronto at the Naturalists' meeting, a very regrettable impression was made by a number of passages in the addresses of Professor William Bateson, the distinguished representative of Cambridge University and British biology. On the morning following his principal address the Toronto *Globe* (December 29, 1921) published, in large letters: "Bateson Holds That Former Beliefs Must Be Abandoned. Theory of Darwin Still Remains Unproved and Missing Link Between Monkey and Man Has Not Yet Been Discovered by Science. Claims Science Has Outgrown Theory of Origin of Species." In intermediate type it announced: "Distinguished Biologist from Britain Delivers Outstanding Address on Failure of Science to Support Theory That Man Arrived on Earth Through Process of Natural Selection and Evolution of Species. Have Traced Man Far Back but Still He Remains Man," and, in smaller type: The missing link is still missing, and the Dar-

winian theory of the origin of species is not proved. This was the verdict of one of the foremost British scientists, Professor William Bateson, director of the John Innes Horticultural Institute, Surrey, England, in the course of an epoch-making address on "Evolutionary Faith and Modern Doubts" at the general session of the American Association for the Advancement of Science, held in Convocation Hall last evening. While declaring that his faith in evolution was unshaken, he frankly admitted that he was "agnostic as to the actual mode and process of evolution." Believing in evolution in "dim outline," he pronounced the cause of origin of species as utterly mysterious.

The speaker then reiterated views expressed in previous addresses. Again quoting the *Globe:*

Referring to the variations occurring in the different species, Dr. Bateson stated that there was no evidence of any one species acquiring new faculties, but that there were plenty of examples of species losing faculties. Species lose things, but do not add to their possessions. "Biological science has returned to its rightful place," said Dr. Bateson, "namely, the investigation of the structure and properties of the concrete of our visible world. We cannot see how the differentiation into species came about. Variation, of many kinds, often considerable, we daily witness, but no origin of species. Distinguishing what is known from what may be believed, we have absolute certainty that new forms of life, new orders and new species have arisen in the earth, but even this has been questioned. It has been asked, for instance, 'How do you know that there were [no] mammals in palæozoic times? May there not have been mammals somewhere on earth though no vestige of them has come down to us?' We may feel confident there were no mammals then, but are we sure? In very ancient rocks most of the great orders of animals are represented. The absence of the others might by no great stress of the imagination be ascribed to accidental circumstances."

It is not surprising that the next day the *Globe* published a signed letter, under the caption, "The Collapse of Darwinism," of which the following is an abstract:

To an audience rarely paralleled in Canada for scientific eminence and influence, the famous Professor Bateson, with amazing frankness, removed one by one the props that have been considered the very pillars of Darwinism. A scientist of international repute, one of the leading, if not the leading evolutionist, of the day, he exposed the weakness of many of the leading planks in the "Origin of Species," and ruthlessly tore down one by one the once fondly believed links in the great chain of Darwinian evolution.

These citations cannot be dismissed as mere newspaper talk of no import. They are called forth by the fact that many of the statements in Bateson's address as cited below are inaccurate and misleading, especially those relating to the origin of species, natural selection, and infertility between species.

It is not true that we do not know how species originate. The *mode* of the origin of species has long been known—in fact, it was very clearly stated by the German paleontologist Waagen in the year 1869, a statement which has been absolutely confirmed beyond a possibility of doubt in the fifty years of subsequent research. It is also true that we know the modes of origin of the human species; our knowledge of human evolution has reached a point not only where a number of links in the chain are thoroughly known but the characters of the missing links can be very clearly predicated. The *cause* of the origin of species is another matter and has been sought in all branches of biology and biological research without an adequate solution having been found. Charles Darwin's theory of selection forms a partial solution of causation and, so far from being discarded, now rests upon much stronger evidence than it did when Darwin enunciated it.

The broad impression conveyed to my mind by the brilliant series of papers in the division of Genetics at Toronto is that genetics is essentially a branch of morphology. It is a running comparison between the morphology of the germ cell and the morphology of the adult. It is in this field, to which Professor Bateson has lent such distinction, that he fails to find either the mode or the cause of the origin of species.

Referring again to the ethical question of the dissemination of scientific truth, I am reminded of the precaution pressed upon me by Huxley from his own experience. He once

told me that before delivering any of his popular addresses he very carefully wrote out every word he intended to say, lest in the heat of enthusiasm at the moment he might say something which would give a wrong impression of the truth. We men of science are far too careless in the application of this Huxleyan advice, especially in our popular addresses, which are eagerly read by the public. We must state the truth so clearly that it cannot be misunderstood and when we give voice to our own opinions we should clearly indicate them as our opinions and not as facts. Bateson's attitude towards Darwinism has been patronizing ever since he began his evolutionary studies. When he refers epigrammatically in a previous address to reading his Darwin as he would read his Lucretius he is indirectly stating an untruth which is calculated to do untold harm. In his Toronto address he *does not clearly distinguish between his own personal opinions based on his own field of observation* and the great range of firmly established fact that is now within reach of every student of evolution who surveys the world of life under natural conditions.

Since writing the above there has come to hand a copy of Professor Bateson's address[1], from which the following excerpts may be made:

Discussions of evolution came to an end primarily because it was obvious that no progress was being made. Morphology having been explored in its minutest corners, we turned elsewhere. . . . We became geneticists in the conviction that there at least must evolutionary wisdom be found. . . . The unacceptable doctrine of the secular transformation of masses by the accumulation of impalpable changes became not only unlikely but gratuitous. . . . Less and less was heard about evolution in genetical circles, and now the topic is dropped. When students of other sciences ask us what is now currently believed about the origin of species we have no clear answer to give. Faith has given place to agnosticism. . . .

. . . But if we for the present drop evolutionary speculation it is in no spirit of despair. . .

Biological science has returned to its rightful place, investigation of the structure and properties of the concrete and visible world. We can not see how the differentiation into species came about. Variation of many kinds, often considerable, we daily witness, but no origin of species. . .

. . . But that particular and essential bit of the theory of evolution which is concerned with the origin and nature of *species* remains utterly mysterious. We no longer feel as we used to do, that the process of variation, now contemporaneously occurring, is the beginning of a work which needs merely the element of time for its completion; for even time can not complete that which has not yet begun. . . .

. . . Meanwhile, though our faith in evolution stands unshaken, we have no acceptable account of the origin of "species." . . .

. . . The survival of the fittest was a plausible account of evolution in broad outline, but failed in application to specific difference. . . . The claims of natural selection as the chief factor in the determination of species have consequently been discredited. . . .

. . . Even in Drosophila, where hundreds of genetically distinct factors have been identified, very few new dominants, that is to say positive additions, have been seen, and I am assured that none of them are of a class which could be expected to be viable under natural conditions. I understand even that none are certainly viable in the homozygous state. . . .

Analysis has revealed hosts of transferable characters. . . . Yet critically tested, we find that they are not distinct species and we have no reason to suppose that any accumulations of characters of the same order would culminate in the production of distinct species. . . .

Twenty yars ago, de Vries made what looked like a promising attempt to supply this so far as *Œnothera* was concerned. . . . but in application to that phenomenon the theory of mutation falls. We see novel forms appearing, but they are no new species of *Œnothera*, nor are the parents which produce them pure or homozygous forms. . . If then our plant may by appropriate treatment be made to give off two distinct forms, why is not that phenomenon a true instance of Darwin's origin of species? In Darwin's time it must have been acclaimed as exactly supplying all and more than he ever hoped to see. We know that that is not the true interpretation. For that which comes out is no new creation. . . .

. . . If we cannot persuade the systematists to come to us, at least we can go to them. They

[1] Bateson, William: Evolutionary Faith and Modern Doubts. Science, January 20, 1922.

too have built up a vast edifice of knowledge which they are willing to share with us, and which we greatly need. They too have never lost that longing for the truth about evolution which to men of my date is the salt of biology, the impulse which made us biologists. . . .

The separation between the laboratory men and the systematists already imperils the work, I might almost say the sanity, of both. . . .

I have put before you very frankly the considerations which have made us agnostic as to the actual mode and processes of evolution. When such confessions are made the enemies of science see their chance. . . . Our doubts are not as to the reality or truth of evolution, but as to the origin of *species*, a technical, almost domestic, problem. Any day that mystery may be solved. . . . That synthesis will follow on an analysis, we do not and cannot doubt.

These passages seem to me to do great credit to Professor Bateson in so far as they contain a frank expression of his opinion that up to the present time neither the causes nor the mode of origin of species have been revealed by the older study of Variation, the newer study of Mutation, or the still more modern study of Genetics. If this opinion is generally accepted as a fact or demonstrated truth, the way is open to search the causes of evolution along other lines of inquiry.

HENRY FAIRFIELD OSBORN
COLUMBIA UNIVERSITY,
DEPARTMENT OF ZOOLOGY,
JANUARY 21, 1922

SCIENCE IN THE PHILIPPINES

EVER since returning from the Philippines in 1919, after a four-year stay, I have had in mind the writing of a brief account of conditions as I found them, especially those conditions which are of interest to the research man, who has wondered how the general status of his profession, and working conditions in the tropics compare with conditions in a large city in the northern part of the United States. My own experience in the tropics is limited to Manila and vicinity, but from my reading and from conversation with others I am of the opinion that conditions in the Philippines, Cuba, Panama, India, Java and other places in the tropics are somewhat similar, independent of the longitude. I have purposely delayed setting down my ideas, because I wished to wait until I could have a fair perspective in comparing experiences in the Philippines with experiences in the United States both before and after my stay there.

There are so many advantages and so many disadvantages to be taken into account that it is difficult to say which location is the more satisfactory for scientific work, and of course, the delights and new interests, and the broadening of one's horizon that come about from travel in the Orient are not to be overlooked. I shall mention only a few points to be considered without making any attempt to give them in the order of their importance.

Climatic conditions are unfavorable in so far as their effect on physical and mental efficiency is concerned. The high temperature and high relative humidity have a tendency to cut down productiveness. To accomplish a given result requires much more energy and determination than in a temperate climate. With the thermometer around 95 to 100 degrees Fahrenheit and the relative humidity between 90 and 100 per cent., the average individual is not so keen about performing his daily activities, especially those which require mental effort.

The general slowing up suffered by the average individual coming to the tropics from a temperate climate is so well understood by old Spanish residents of the Philippines that they divide all foreigners into three classes. There are the *Ricien Nacidos*, those who have been in the islands not to exceed two or three years, or literally, the "recently born." The middle class consists of those who have been there for five to ten years, and are beginning to become modified by the environment. The last class is called the *Platinos*, or "bananos." This class is supposed to have eaten so many bananas that they have become sleepy and torpid, have lost much of the industry of a temperate climate and have settled down and become a part of the general scheme of life in the tropics.

The separation from scientific societies and the opportunity to discuss problems and compare notes with others of the same profession

must be admitted is a serious disadvantage. The range of acquaintanceship with persons engaged in his own class of work is limited and while there are a few science organizations these are small in comparison with those that can be enjoyed in an American city. The result is that, although one often spends more time in reading books and journal articles than if he were here, he finds on his return that a number of things of importance have transpired in the science world of which he either did not hear, or which failed to make much of an impression on him.

Work is often retarded by failing to get supplies promptly. It so happened that during my stay in the Philippines this condition prevailed all over the world, but it was worse there and is more or less chronic. If supplies are ordered from the United States, they cannot be expected in less than three months. To receive them in such a short time means that the stock was on hand at the supply house when the order was received and that there was no delay in filling the order. The time may be shortened, of course, by sending a cablegram, but unless definite arrangements are made and a special code established, this procedure is not practicable in general. With the cable rate from Manila to New York more than a dollar a word it may be seen that cable messages are justifiable only in rather unusual circumstances. If the order, when it arrives in Chicago or New York, is not filled with care and dispatch, another month or two may elapse. Usually it is not safe to count on delivery of goods in less than six months. It frequently happens that the manufacturer or dealer in America does not realize how long a time is required for an exchange of correspondence and will write requesting some further information, which means a delay of another three months, and so on.

On one occasion I ordered a pyrometer from a well known manufacturer in the United States. The order was sent by mail, but marked rush, and we hoped to receive the instrument within three or four months. At the end of that time, a letter was received, asking whether the wall type or table type of galvanometer was preferred. This was answered at once, stating that the table type was preferable. Several months later another letter came, this time asking whether we desired the scale to be graduated in Fahrenheit or Centigrade. By this time our work had been held up so long and we were so disgusted by the long delay that we at once cabled him to send the Centigrade scale. Practically a year from the date of the original order, the instrument arrived. Possibly a little profanity was justifiable when on unpacking the pyrometer, it was found that he had sent the Fahrenheit scale. Of course, this is an extreme case, but serves to illustrate the serious disadvantage of being separated by 10,000 miles from a supply house where a large stock of chemicals and apparatus may be obtained immediately. In Manila, as a rule, such materials are handled by drug stores and the limited stocks which they carry are available only to tide over until regular orders can be placed. Usually the chemicals in stock are primarily for pharmaceutical purposes, and not many chemically pure reagents are to be had.

Such compounds as ferrous salts seem to become oxidized much more rapidly than here; although I have seen no actual data to that effect. Also a number of compounds which do not take up moisture rapidly in a dry climate, do so there. On one occasion I bought an ounce or two of sodium thiosulphate for some photographic work. After completing the work, I left the remainder of the chemical in its original container which happened to be a paper bag and placed it in a drawer of the library table. On pulling out the drawer a few days later I was surprised to find considerable water which had wet a number of articles in the drawer. On looking for the source I found that the chemical was saturated with water and that it was necessary to keep it in a tight container. Chemicals for use in the tropics should be ordered in small containers so that if a portion is removed and the remainder is allowed to stand for a time, the loss will not be great. Although the cost of chemicals in quarter-pound bottles is slightly higher than in pound bottles, the saving and satisfaction more than repay the extra cost.

The deterioration of instruments and appara-

tus is especially troublesome. Almost any metal except gold or platinum will corrode rapidly if given half a chance. A number of experiences soon bring this to the attention of a new arrival in the islands. Wire paper fasteners must be made of brass if it is desired to keep pamphlets and magazines in good condition. After a short time, ordinary iron wire fasteners corrode to such an extent that the paper in contact with them is discolored from iron rust. Ordinary iron wire paper clips rust so rapidly that after a year or two they cannot be removed without being bent out of shape. The frames of cameras made of metal covered with leather go to pieces in some cases. The alloy becomes oxidized and pushes off the leather cover. Of course, it is an easy matter to remove the covering of oxide and replace the leather, but in a short time, more moisture has been absorbed and corrosion has taken place a second time.

These are trivial things compared with what happens to delicate physical apparatus of all kinds. It seems almost impossible to protect instruments from atmospheric moisture to such an extent that corrosion does not begin, and if this continues long enough the piece of apparatus is worthless. In many cases the corrosion does not justify replacement, but does demand restandardization. In order to get satisfactory results with pyrometers, galvanometers and the like it is necessary to restandardize them frequently, and this requires considerable time. Too long a time would be required to return the apparatus to the manufacturers for repairs and restandardization. Even glass lenses of microscopes, telescopes, cameras and the like are not immune. If they are not used for a time, they become spotted, and often have to be repolished.

Reliable skilled assistants are difficult to obtain. The demand for them is somewhat limited and every position is filled. However, there does not seem to be a position vacant nor a man out of employment. Most of the positions are filled by Europeans or Americans, though there is an ever increasing body of Filipinos trained in science. The difficulty is that there is very little flexibility to the system. If one man returns to the States or leaves his regular position for any reason, it is almost impossible to replace him without a long delay of correspondence back and forth to the United States and during this time, it often happens that valuable pieces of research are held up and interest is lost in them, because no one can be found to carry on the work.

Thus far I have mentioned only the tribulations of scientists in the tropics and I wish to protest against any charge of exaggeration. The account is not overdrawn and all of the items mentioned have come under my personal observation, and I believe anyone who has had experience in the tropics will verify them. However, there is another side, as I have previously mentioned. In this connection, the first thing which I shall discuss is the great interest and fascination of the various research problems which one encounters in the Philippines. The field is comparatively new and if one has some idea or plan for research, the chances are that on investigation, he will not find that it has been trampled over, but that he has practically a carte blanche. Although extensive research has been carried on at the Bureau of Science and elsewhere for the past decade or two, nevertheless the vast number of problems waiting to be solved have scarcely been touched.

While skilled assistants are few and difficult to obtain, unskilled help is plentiful. Filipinos are adapted physically to careful manipulation and some of them are very satisfactory indeed. The salary for such a position is much lower than here and a number of helpers are often available—which greatly expedites the work. The climatic conditions make the average American irritable and perhaps unusually hard to please, and while he is in the islands he is likely to believe that his unskilled assistants possess little merit and are difficult to direct, but when he looks back at his experiences, he is likely to change his mind materially and wish he could have half a dozen *muchachos* in his laboratory in the States.

Generally the laboratory is in a building of only one or two stories. This is very satisfactory because there is much less danger from fires and accidents. The uniform temperature greatly adds to the flexibility of the laboratory.

If the train of apparatus to be set up is too long for the room available, some of it may be put outside the laboratory. There is no question of cold and heat to be taken into account and during most of the year all that is needed is protection from the sun. There is always the advantage of good light and air and freedom from soot and dirt. Laboratory work is practically out-of-door work. There is no heating system, and no frozen pipes to be dreaded.

J. C. Witt

Chicago, September 10, 1921

CHARLES HENRY DAVIS 2ND

Charles Henry Davis 2nd, Rear Admiral, retired, U. S. Navy, who was twice Superintendent of the Naval Observatory, died at Washington, D. C., December 27, 1921.

He was born in Cambridge, Mass., August 28, 1845, the son of Charles Henry Davis and Harriette Blake Mills.

Admiral Davis graduated from the Naval Academy in 1864. From 1875 till 1885 he was engaged principally in astronomical work, at first in the Naval Observatory at Washington, in the Department of Chronometers, and then in expeditions for the determination of longitudes by means of the submarine cables. Also, the latitudes of many stations were determined by Talcott's Method.

In No. 6, Navy Scientific Papers, published by the Bureau of Navigation, are given the investigations by Davis of Chronometer Rates as affected by Temperature and other Causes. The results of the longitude expeditions are presented in three publications of the Navy Hydrographic Office: with Lieutenant-Commander Francis M. Green and Lieutenant J. A. Norris "Telegraphic Determination of Longitudes, embracing the Meridians of Lisbon, Madeira, Porto Grande, Para, Pernambuco, Bahia, Rio de Janeiro, Montevideo, and Buenos Aires, with the latitudes of the Several Stations"; also with Lieutenant-Commander Green, and Lieutenant Norris, "Telegraphic Determination of Longitudes in Japan, China, and the East Indies, embracing the meridians of Yokohama, Nagasaki, Vladivostok, Shanghai, Amoy, Hong-Kong, Manila, Cape St. James, Singapore, Batavia, and Madras, with the latitude of the several Stations"; with Lieutenants Nornis and Laird, "Telegraphic Determination of Longitudes in Mexico and Central America and on the West Coast of South America, embracing the meridians of Vera Cruz, Guatemala, La Libertad, Paita, Lima, Anca, Valparaiso, and the Argentine National Observatory at Cordoba, with the Latitudes of the Several Sea-Coast Stations."

Davis as a Captain was Superintendent of the Naval Observatory from July, 1897, to April, 1898, leaving the Observatory to command the Dixie in the Spanish War. He returned to the Observatory in November, 1898, and remained on duty there as Superintendent until November, 1902. As Superintendent, Captain Davis took an active and successful part in the completion of the equipment of the New Naval Observatory and in formulating plans for the work to be carried on.

In 1904 Davis was made a Rear Admiral, and in 1904 and 1905 he was the U. S. representative on the international commission of inquiry on the North Sea incident which sat in Paris.

After service at sea as Squadron Commander, Admiral Davis was retired August 28, 1907. He continued to be interested in astronomy after his retirement, by reason of his achievements in science and because of his long service at the Naval Observatory.

His father, also a Rear Admiral, had twice been Superintendent of the Observatory and had established the Nautical Almanac Office.

SCIENTIFIC EVENTS

BRITISH SCIENTIFIC INSTRUMENTS[1]

The exhibition of British scientific instruments held under the auspices of the Physical Society and the Optical Society at the Imperial College of Science and Technology, of which a description was given in our columns last week, is a timely reminder of the importance of scientific instruments in the national economy. Modern civilization is based, and must be increasingly dependent, on the extension of

[1] From Nature.

scientific knowledge and its applications to industry; and in these developments scientific instruments are an essential and predominant factor.

Of the part played by scientific instruments in the advancement of scientific knowledge there is no need to speak. The laboratories of the universities and kindred institutions where scientific research is prosecuted would be disabled were they without scientific instruments of the highest trustworthiness and precision. The variety and extent of the industrial purposes served by scientific instruments are so great that there is probably no important industry in the country which is not dependent on scientific instruments of one kind or another for the performance of its productive functions. Moreover, the field of application of scientific instruments is constantly widening; the uses of the microscope in the textile and steel industries, of the polarimeter in the sugar and essential oil industries, of the pyrometer in the metallurgical industry, and of X-rays in the iron and steel industries, are but a few of the many examples that could be cited to illustrate the invasion of scientific instruments into fields of industry in which they were at one time unknown. That the industries gain in sureness and accuracy and in a deeper and wider knowledge of the fundamental scientific principles involved is obvious. And the process continues and must continue. Tomorrow new instruments will be devised and new uses found for old instruments.

Moreover, as was stated in the leading article published in NATURE of February 10, 1921, the scientific instrument industry, springing directly from the loins of science, and progressing as scientific knowledge widens, is one of the most highly skilled industries we have. Its expansion means a definite increase in the numbers of academic and technical scientific workers and of the most highly skilled artisans; and the national wealth, in any comprehensive conception of the term, must be enlarged by the increase of the numbers of such educated and skilled classes.

For these and other reasons a flourishing and efficient scientific instrument industry is vital to the nation, whether in peace or war. And, although it is obvious that the users of scientific instruments, whether in the industrial or academic domain, must not be prejudiced or hampered by being unable to obtain the best instruments, from whatever source, it would be a disaster of the first magnitude if British scientific instruments should not be produced equal to the best that the world has to offer.

AN ENGLISH JOURNAL OF SCIENTIFIC INSTRUMENTS[1]

NATURE may be continuous and the divisions of time and space no more than artificial articulations devised to suit the human intellect. Nevertheless, physical science is based on measurement, and proceeds only by the use of selected units of time, space, quantity, and so forth. Every new branch of science leads to the creation of a new set of units, and according to the latest theory it would appear that energy itself is most conveniently regarded as divided into "quanta"—measurable and related units. Many of the most illuminating advances in theory and actual discoveries of fact have come about by more refined methods of weighing and measuring. By these, argon, radium, and many new elements have been isolated and identified; by these the structure of the atom and the new alchemy which transmutes one element into another have been revealed. In every laboratory a new research implies the devising of new apparatus or the detection of deficiencies in existing apparatus. The literature in which such advances in technical methods are published is scattered all over the civilized world. It is written in many languages and at present there is no adequate system of indexing or recording it. Doubtless the patent offices contain sufficient descriptions of improvements with actual or possible commercial value; but even this field is so vast that applicants have to employ special agents before they can guess if their claims are novel. But for a large proportion of the methods devised in the prosecution of research patents are neither sought nor desired. Sir Richard Glaze

[1] From the London Times.

brook, when director of the National Physical Laboratory, recognized the waste of time and the duplication of effort arising from this confusion. He had his opinion confirmed by many men of science, Government Departments, trade associations, and private firms. His successor, Sir Joseph Petavel, and the Advisory Council of Scientific and Industrial Research have taken up the question where he left it, and now hope to found a journal to deal with the methods of measurement and instruments. A preliminary number is being prepared under the direction of the Institute of Physics, the Research Department, and the National Physical Laboratory. It is hoped that the distribution of this, the cost of which is to be borne by the Department of Scientific Research, will secure sufficient support to place the venture on a permanent basis. There can be no doubt that the establishment of the proposed journal would be of value to the progress of all branches of scientific work.

JOURNAL OF THE OPTICAL SOCIETY OF AMERICA AND REVIEW OF SCIENTIFIC INSTRUMENTS

During the past few years there has been an increasing appreciation of the need in America of a journal devoted to scientific instruments of all kinds. This need is due to a number of causes. The ever increasing volume of scientific material which is being offered for publication is so crowding many of our journals that space does not permit an adequate description of apparatus used. Further, many instruments and instrumental methods, developed for a single experiment, can be applied to a variety of measurements. If described only in connection with the work for which they were developed, the description is relatively inaccessible since it is subsidiary to the main scientific discussion of the article.

In many sciences there is no medium for the publication of articles describing apparatus primarily for pedagogical purposes in lecture demonstrations and laboratory. Such short articles or notes should serve a very useful purpose since every real teacher is always on the lookout for means of improving his teaching. Further, newly developed apparatus and methods of one science are very frequently applicable to work in another science. A medium of publication readily accessible to all would save much time and energy.

The first steps toward the development of an instrument journal were taken by the National Research Council and the Association of Scientific Apparatus Makers of the United States of America in jointly taking under advisement the establishment of a new journal for the purpose. After extensive consideration it seemed unwise to start an independent journal. Finally representatives of the Optical Society of America, which was publishing a bi-monthly journal under the title *Journal of the Optical Society of America,* were invited to a conference which ultimately resulted in an arrangement whereby the Optical Society, cooperating with the National Research Council and the Apparatus Makers Association, is to add to its journal a section on scientific instruments. The enlarged journal is to be published under the title *Journal of the Optical Society of America and Review of Scientific Instruments,* and will be issued monthly, beginning with May, 1922. It will be under the direction of an editorial board composed of Dr. P. D. Foote, Bureau of Standards, editor-in-chief; Professor F. K. Richtmyer, Cornell University, assistant editor-in-chief and business manager; and a representative board of associate editors.

In addition to articles on theoretical, experimental and applied optics in the section on optics of the new journal, there will be published in the instrument section original articles on scientific instruments of all kinds (*i. e.,* electrical, mechanical, etc., as well as optical) for research and instruction in chemistry, physics, biology and other sciences. The editors announce that they will be glad to receive manuscripts for publication, and suggestions as to desirable subject matter to include in the journal.

GIFT OF THE PROCEEDS OF RESEARCH FOR RESEARCH

On January 26, 1922, a contract was signed between The Babies' Dispensary and Hospital and the W. O. F. Laboratories Company, Cleveland, Ohio, in connection with the manu-

facture of S. M. A.—an artificial food adapted to mother's milk and developed by Dr. H. J. Gerstenberger, medical director of The Babies' Dispensary and Hospital and professor of Pediatrics of Western Reserve University Medical School, who has transferred all of his rights to The Babies' Dispensary and Hospital.

S. M. A. is said to represent an improvement over the older attempts at making an artificial food for infants more like human milk in that it contains a fat that in its saponification, iodine, and Reichert-Meissl numbers is like the fat of woman's milk, and in that it further possesses decided anti-spasmophilic and anti-rachitic powers. The latter are at least partly due to the use of codliver oil in the making of the S. M. A. fat.

S. M. A. was fed to dispensary and hospital infants under careful supervision from 1915 to 1920. During January, 1920, it was made available to the medical profession of Cleveland with excellent results, as can be realized from the increase in sales per month, being 1,000 quarts at the beginning and 20,000 quarts during December, 1921. During November, 1920, S. M. A. was put up in powder form, and a year later was made available to the medical profession throughout the country.

As a result of this contract the Babies' Dispensary will receive a minimum of $10,000 per year. To meet the request of Dr. H. J. Gerstenberger, the contract contains a clause limiting the use of the funds to research purposes.

Inasmuch as The Babies Dispensary and Hospital will be the future department of pediatrics of Western Reserve University Medical School, it is hoped that this accomplishment will aid in the prompt development of the pediatric unit of the new medical group of Western Reserve University.

PROFESSOR J. W. TOUMEY AND THE YALE SCHOOL OF FORESTRY

APPRECIATION of the part played by Dean J. W. Toumey, of the Yale School of Forestry, in securing Mr. Henry S. Graves as his successor, and satisfaction in the former's decision to continue in the service of the university as Morris K. Jesup professor of silviculture, is expressed in a vote passed by the Yale Corporation. It was due to Professor Toumey's initiative and wish that efforts were made to induce Mr. Graves to return to the university as head of the School of Forestry. The vote of the corporation follows:

Voted, in accepting, at the request of Professor James W. Toumey, his resignation as dean of the School of Forestry, to record the satisfaction of the president and fellows that he is to remain in Yale's service as Morris K. Jesup professor of silviculture, and to spread upon the minutes of the corporation an expression of its gratitude to him for his successful administration as acting director and then as dean. During this, and due to his untiring interest and enthusiasm, this youngest of Yale's schools has gained largely in endowment, extended its educational scope, and added both to its equipment in New Haven and to its facilities for instruction in the field through the acquisition of the school forests in Connecticut and in New Hampshire. The corporation recognizes with pride and gratitude that no other school of Yale University has enjoyed a more remarkable and better planned development than has the School of Forestry under Dean Toumey's administration, the close of which is fittingly marked by the successful consummation of two projects nearest his heart. One of these is the acquisition by the School of Forestry of a building adequate for its needs; the other is the return to Yale University as head of the school of Henry S. Graves, B.A. 1892. The fact that the movement to bring the latter back as dean originated with Professor Toumey is but one example from many which might be cited of his desire to see the school take advantage of every opportunity before it and of his constant, loyal and unselfish devotion to its welfare.

SCIENTIFIC NOTES AND NEWS

THE annual meeting of the National Academy of Sciences will be held at the United States National Museum, Washington, on April 24, 25 and 26.

DR. GEORGE E. HALE has resigned as president of the Pacific Division of the American Association for the Advancement of Science to attend the meeting of the International Research Council in Brussels. Dr. Barton Warren

Evermann, director of the Museum of the California Academy of Sciences, has been elected president to succeed Dr. Hale, and will give the address at the meeting to be held in Salt Lake City from June 22 to 24. It will be remembered that the American Association for the Advancement of Science will hold a summer meeting at Salt Lake City in conjunction with the Pacific Division.

WE learn from *Nature* that a portrait of Sir Patrick Manson was unveiled by Sir James Michell at the London School of Tropical Medicine on January 20. The portrait was subscribed for by a large number of past and present students and other friends at home and abroad.

THE board of managers of the Hospital of the University of Pennsylvania will extend the age limit for professors to enable Dr. John B. Deaver to continue as head of the surgical department of the University Medical School. Dr. Deaver will be 67 years old on July 25, and the board of managers was unanimous in the desire to retain him.

DR. SMITH ELY JELLIFFE has been elected president of the New York Psychiatric Society.

BRADLEY STOUGHTON, formerly secretary of the American Institute of Mining and Metallurgical Engineers, was elected president of the Yale Engineering Association at the annual meeting on February 2, 1922.

DR. HAROLD PENDER, director of the department of electrical engineering at the University of Pennsylvania, was recently appointed chairman of the standards committee of the American Institute of Electrical Engineers.

MR. JOHN G. SULLIVAN was elected president of the Engineering Institute of Canada for 1922 at the annual meeting held in Montreal from January 24 to 25.

WE learn from *Nature* that shortly after the retirement of Professor P. F. Frankland from the Mason chair of physics in the University of Birmingham a fund was opened with the object of providing some permanent memorial of his work in the university. The money subscribed was devoted in the first place to a portrait of Professor Frankland (painted by Mr. Bernard Munns), which now hangs in the great hall of the University at Edgbaston. The balance of the fund has been applied to the institution of a Frankland medal, which, together with a prize of books, is to be presented annually to the best student in practical chemistry.

THE council of the Geological Society has this year made the following awards: Wollaston Medal, Alfred Harker; Murchison Medal, John William Evans; Lyell Medal, Charles Davison; Wollaston Fund, Leonard Johnston Wills; Murchison Fund, Herbert Bolton; Lyell Fund, Arthur Macconochie and David Tait.

THE Prince Albert of Monaco and Professor G. O. Sars, of Christiania, were elected foreign members of the Zoological Society of London at its monthly meeting on December 21.

IN the recent reorganization of the Russian Soviet cabinet, three new portfolios were created, one of them for public health, in which Dr. Semashko has been placed in charge.

DR. LESTER A. PRATT, who has been in charge of the research laboratory of the Merrimac Chemical Company, Boston, for the past six years, has been made director of research in the same institution.

EDWARD A. DIETERLE, assistant chief chemist of the Koppers Company, Pittsburgh, Pa., has been made chief chemist of the Chicago By-Product Coke Company, Chicago.

DR. CARL S. OAKMAN, of the Digestive Ferments Company, Detroit, has accepted the general managership of the Wilson Laboratories, Chicago.

PROFESSOR JACOB R. SCHRAMM, of the department of botany of Cornell University, has been granted a leave of absence for work in Washington on *Botanical Abstracts*.

PROFESSOR STEPHEN S. VISHER has resumed his teaching of geography at Indiana University after spending nearly six months in a field study of the tropical cyclones of the Pacific. The investigation was financed by the Bishop Museum of Honolulu and by Yale and

Indiana Universities. Dr. Visher studied in the Hawaiian, Fijian and Philippine Islands and in Australia, coastal China and Japan.

DR. HOWARD S. REED, professor of plant physiology in the University of California, is spending the winter in the West Indies and Central America, in travel and in observation of the citrus industry.

J. S. NEGRU, managing editor of *Chemical and Metallurgical Engineering*, sailed for Europe on February 11, for a six months trip through Germany, France, Belgium and other European countries. The purpose of the trip is to study industrial and economic conditions and observe the latest advances in engineering and technology.

LEAVE of absence has been granted a party of naturalists from the State University of Iowa to spend the summer of 1922 in the Fiji Islands and New Zealand. The party will consist of Professor C. C. Nutting, zoologist, who will act as leader; Professor R. B. Wylie, botanist; Professor A. O. Thomas, geologist; Assistant Professor Dayton Stoner, entomologist and ornithologist; Mrs. Dayton Stoner, assistant entomologist, and Mr. Waldo S. Glock, assistant geologist.

DR. J. GORDON THOMPSON, lecturer on protozoology at the London School of Tropical Medicine, has, at the invitation of the British South African Country, gone to Rhodesia to investigate protozoological diseases. Dr. Thomson sailed on January 5 and expects to be absent six months. He will give special attention to the etiology of blackwater fever.

PROFESSOR H. S. LANGFELD, of Harvard University, delivered an address on "Instinct and War" at an open meeting of the William James Club of Wesleyan University on December 4. Professor E. G. Boring, of Clark University, addressed the club on February 10, on "The Changing Status of Introspection."

DR. HAWLEY O. TAYLOR gave a course of twelve lectures on auditorium acoustics at Franklin Union, Boston, beginning on January 3. The lectures were addressed particularly to architects and builders and treated the subject in a way to enable architects to satisfactorily adjust the acoustics of the rooms which they design.

ON February 9, Professor J. Howard Mathews, chairman of the department of chemistry of the University of Wisconsin, addressed the Purdue Section of the American Chemical Society on the subject "Some of the Research Methods and Research Problems of Photochemistry."

DR. J. C. BLOODGOOD, of Baltimore, Associate Professor of Clinical Surgery at the Johns Hopkins Medical School, gave a Mayo Foundation Lecture, January 14; he discussed "The present day trend of surgery and pathology and the outlook for the future."

DR. ROGER I. LEE, professor of hygiene, Harvard University, lectured before the School of Hygiene and Public Health, Johns Hopkins University, on "The physical examination of large groups of individuals," at its regular weekly lecture, February 6.

DR. J. A. DETLEFSEN, of the University of Illinois, delivered a lecture before the Royal Canadian Institute at Toronto on January 21, on "Recent experiments bearing upon the inheritance of acquired characters."

PROFESSOR H. A. BROUWER, of Delft, Holland, who is exchange professor in the University of Michigan for the spring semester, will deliver a course of lectures on the "Geology of the Dutch East Indies." He will also deliver a series of more popular lectures upon "The people and geology of the East Indies."

THE annual meeting of the Eugenics Research Association will be held at Cold Spring Harbor, Long Island, Saturday, June 10, 1922. The title of Dr. Lewellys F. Barker's presidential address is "Heredity and the Endocrine Glands."

PROFESSOR LEFFLER, of Stockholm, is endeavoring to organize an International Congress of Mathematicians, to be held at Stockholm in the coming summer.

THE Royal Society of Archeology of Brussels has formed a section of the history of

medicine, the first meeting of which was held on December 9. Dr. Mélis was appointed president, and Dr. Muls of Brussels, secretary.

Dr. Ella B. Everitt, professor of gynecology at the Woman's Medical College, Philadelphia, was killed on January 24 when her automobile collided with a motor truck.

The Yale *Alumni News* writes: "The late Professor Joseph Paxson Iddings, of the United States Geological Survey, a graduate of the Sheffield Scientific School in the Class of 1877, and who had a distinguished career as a teacher and research worker in the field of petrology, was always greatly interested in the work of petrology at Yale, and especially in the work of his friend, the late Professor Pirsson. Dr. Iddings gave, some years ago, the Silliman Lectures at Yale University, and he was for many years connected with the University of Chicago as professor of petrology. Through a gift from his sister, Mrs. Estelle Iddings, Cleveland, the entire portion of Dr. Iddings' estate, amounting to over $25,000, has been presented to the Board of Trustees of the Sheffield Scientific School, the income of this fund to be used for the promotion of research work in petrology. During the life of one person a portion of the income of this fund will not be available, but there will be established for the next university year a scholarship of $500 open to a properly qualified student in the graduate school of the university competent to carry on research work in petrology. This scholarship is to be known as the Joseph Paxson Iddings Scholarship in Petrology. The award of this scholarship is, by the terms of the gift, in the hands of a committee composed of the director of the Sheffield Scientific School and the professor of geology, who is a member of the Governing Board of the Sheffield Scientific School."

Attention is called in *Nature* to the fact that on January 2 occurred the centenary of the birth of Rudolf Julius Emmanuel Clausius, the distinguished mathematical physicist and the predecessor of Hertz in the chair of natural philosophy at Bonn. The son of a pastor and schoolmaster, Clausius was born at Koslin, in Pomerania, and after attending the gymnasium at Stettin, spent four years at Berlin, where he studied under Dirichlet, Steiner, Dove, and Magnus. Before going to Bonn he held appointments at the Royal Artillery School, Berlin, Zürich Polytechnic, and Würzburg University. Recognized as one of the founders of the science of thermo-dynamics, it was in his memoir to the Berlin Academy of Sciences in 1850 that he re-stated Carnot's principle in its correct form. To him is also due the conception of entropy. His chief work, "Die Mechanische Wärmetheorie," appeared in 1867. The kinetic theory of gases and the theory of electrolysis also owed much to his labors. He was called to Bonn in 1869, served as Rector of the University during 1884-85, and died there on August 24, 1888.

The House of Representatives has passed the Lampert bill to increase the salaries of the chief or principal examiners of the Patent Office from $2,700 to $3,900 per year and those of the assistant examiners by amounts ranging from $150 to $900 per year. The bill provides an increase of force to the extent of one law examiner, 26 assistant examiners, and 22 clerks.

UNIVERSITY AND EDUCATIONAL NOTES

The will of Amos F. Eno, disposing of $13,000,000 or more, is declared invalid by a surrogates' court jury on the ground that Mr. Eno was of unsound mind when he executed it. It is the second time the will has been declared invalid in surrogate's court, the appellate division having ordered a retrial. The will was executed in June, 1915, two months before Mr. Eno's death. His estate has increased since then, so that the distribution under the document now would have been approximately: Columbia University, between $5,000,000 and $6,000,000; other institutions, $3,000,000, and relatives, $4,600,000. Besides the residuary bequest to Columbia University Mr. Eno bequeathed to New York University, the American Museum of Natural History, the Metropolitan Museum of Art and other institutions, $250,000 each. The largest cash beneficiary

was the General Society of Mechanics and Tradesmen, to which the testator left $1,800,000.

THE will of Cora M. Perkins gives her residuary estate to Columbia University, in addition to a direct bequest of $30,000 for chemical research.

A REUTER dispatch from Brussels states that Louvain University has received a legacy of $100,000 toward erecting a special building for cancer research.

DR. M. C. MERRILL, professor of horticulture at the Utah Agricultural College, has been appointed professor of horticulture and dean of the new College of Applied Arts at the Brigham Young University, Provo, Utah.

T. L. Patterson, Ph.D., formerly of the physiological department of the State University of Iowa College of Medicine, has been appointed professor and director of the department of physiology at the Detroit College of Medicine and Surgery.

DR. ALICE SULLIVAN has sufficiently recovered from her accident of last summer in the Colorado floods to assume her position as instructor in psychology at the University of Illinois.

DISCUSSION AND CORRESPONDENCE

KILOBAR, KILOCAL, KILOGRAD

IN a letter just received from The Meteorological Office, Professor Whipple very kindly informs me of the result of a question put to the Secretary of the Chemical Society regarding the attitude of British chemists regarding the *bar*.

While the opinion expressed is to be regarded as unofficial, Professor Philip says:

"Your letter in reference to the definition of the 'bar' was considered by our Publication Committee. The general opinion is that very few English chemists use the 'bar' as a unit of pressure on either basis. There was a feeling, however, that in view of the use of the 'bar' in Langmuir's papers and other communications emanating from the same quarter (see *e. g.* Dushman in the *General Electric Review*, 1920-1) English chemists would be more likely to use the 'bar' in that sense than in the sense employed by meteorologists."

It will be recalled that meteorologists in 1913, quite unaware of the fact that the *bar* had been accurately defined by Professor T. W. Richards in 1903, and thinking they were coining a new word, adopted the *bar* as the unit of pressure but gave it the value of a *megabar*. My friendly correspondent, a meteorologist of prominence, adds: "This looks as if the confusion is likely to spread. We shall have a permanent ambiguity like those in the words *billion* and *calorie*."

To this, I have answered: There need be no confusion if meteorologists will simply write *kilobar*, where they now use *millibar*.

The practical unit of pressure is 1000 *bars*, the *bar* being the pressure expressed in terms of force which will give an acceleration of 1 centimeter per second per second to one gram of matter.

It is the natural basic unit, strictly C. G. S. and was in legitimate use by chemists and physicists 10 years previous to its appropriation by meteorologists.

With regard to the calorie, it will no longer be necessary to specify the calorie as the gram calorie or therm. The word *calorie* by itself will mean the amount of heat that will raise the temperature of a gram of pure water from 1000 to 1003.66 Kelvin-kilograds. The larger unit, much used by engineers, being the amount of heat required to raise the temperature of one kilogram of water, can be called the *kilocal*.

The scale of temperature which has been used without difficulty at Blue Hill Observatory for the last five years, makes the thermal coefficient of the expansion of a gas (air) at constant pressure .001 instead of .00366.

This is very easily accomplished by making zero on the scale, the absolute zero (—273.12° Ac) and making the freezing point of pure water at megabar pressure, 1000. There are numerous advantages in the use of the scale. When used in connection with kilobar pressure, values of temperature and pressure are

decimalized; and equations in thermodynamics require about half the old style multiplication and division.

It may be noted that, unlike the Fahrenheit and Centigrade which depend upon the boiling point of water, a variable quantity, depending upon pressure, and hence not the same from one day to another, or even from one place to another, the Kelvin-kilograd uses only the freezing point. The effect of change of pressure on the freezing point is so small compared with the boiling point that the correction is practically negligible.

ALEXANDER MCADIE

BLUE HILL OBSERVATORY,
JANUARY 30, 1922

THE GEOLOGY OF WESTERN VERMONT

IN a paper entitled "Studies in the Geology of Western Vermont," published in the Twelfth Biennial Report of the Vermont State Geologist, pp. 114 to 279, the writer has described field relations among the lower and middle Ordovician strata along the eastern shore of Lake Champlain in the townships of Benson, Orwell and Shoreham which seem best explained as great dislocations in the forms of reverse faults and one or more low-angle thrusts by which certain massive dolomite and limestone strata of lower Ordovician age have been broken and moved westward for indeterminate distances over shales and interbedded black slates and limestones belonging to the same geological system, but undoubtedly younger in age.

Similar phenomena were described also for the lake region near Burlington, where, however, thrust phenomena had long been better known. In the northern areas, so far as studies had then been carried by the writer, the presence of lower Ordovician limestones on middle Ordovician slates seemed largely confined to the islands of the lake, while on the mainland of Vermont certain siliceous dolomites and quartzites belonging to the Cambrian system and to the lower Cambrian terrane were found reposing on black slates with interbedded limestone bands not very different from those found beneath the lower Ordovician limestones on the islands and on the mainland farther south in Orwell and Benson.

In addition to the description of the more or less clearly defined deformations just referred to the writer offered field evidence in support of the view that similar dislocations may probably define the fundamental deformational features of the rocks within parts of the Taconic Range, and along the "Vermont Valley" and the western margin of the Green Mountain plateau contiguous thereto, although within the latter-mentioned areas the thrust relations have been much disguised by normal faulting.

In the summer of 1921 the writer continued his studies in western Vermont among the islands of Lake Champlain and along the mainland in Phillipsburg, Quebec, and in the Vermont towns of Highgate, Swanton, Sheldon, St. Albans, Georgia, Fairfield, Fairfax, Milton and Colchester. Although there are present in these areas certain differences in respect to deformation and erosion, with which in some degree apparently are to be correlated the former extent and present boundaries of the lake in its northern portions, and also certain geographical variations, chiefly in the rocks composing the lower Cambrian beds in northern Vermont, the major thrust relations are clearly defined. Many interesting structural details were noted.

It is purposed, at the first opportunity, to continue these later studies thus begun and to publish a second paper on the geology of western Vermont, dealing chiefly with deformational features among the islands of Lake Champlain and along the Vermont shore region of the lake as far south as Shoreham.[1]

C. E. GORDON

AMHERST, MASS.,
NOVEMBER 1, 1921.

ACUTE SENSE OF SOUND LOCATION IN BIRDS

IN a recent issue of SCIENCE,[1] Dr. A. G. Pohlman, of the St. Louis University School of Medicine, briefly discusses some matters pertaining to the ability of birds to locate the

[1] Published with the consent of the Vermont State Geologist.

source of sounds, under the heading, "Have Birds an Acute Sense of Sound Location?" He closes by saying that he would appreciate any direct observational data touching upon this subject. The following is an affirmative answer to his question:

On the morning of September 9, 1921. when in camp near Kneeland post office, Humboldt County, California, while I was seated among some rather tall bushes, watching for sparrows, a Sharp-shinned Hawk (*Accipiter velox*) flew on to a lower limb, some thirty or forty feet above the ground, of a dead fir tree about seventy yards away, alighting with its back toward me. While the bird was visible to me through the small openings among the branches of the bushes I must have been absolutely hidden from its view.

Just to see what the result would be I squeaked in imitation of a wounded bird when, to my great astonishment, the hawk wheeled as if on a pivot with remarkable rapidity and darted in a bee line over the tops of the bushes straight in my direction. When it reached the spot directly over my head, and not six feet above me, it evidently was aware that it had reached the center of the sound field for, not seeing anything there to account for the sound, it shot abruptly up into the air and lit on a limb of another dead fir so close to me that I shot it with my 32 caliber auxiliary barrel with a small charge of No. 12 shot.

The most curious part of this incident is that the hawk did not stop to listen and analyze or locate the sound, as might a jay for instance, but with the first squeak it turned quick as a flash, and darted with arrowlike speed for the spot from which the sound emanated; that is to say on the exact line (more correctly, vertical plane) between its perch and the spot, as the height of the bushes prevented it from aiming its flight quite low enough. It seemed to me that if my head had been high enough to be above the bushes it would have struck me.

This was the most remarkable exhibition of instantaneous precision in locating sound, not only as concerns direction but also as to rapidity of impulse, that it has been my good fortune to witness.

[1] SCIENCE, New Series, Vol. LIII, No. 1375, May 6, 1921, p. 439.

JOSEPH MAILLIARD
CALIFORNIA ACADEMY OF SCIENCES,
SAN FRANCISCO, CALIFORNIA

SCIENTIFIC BOOKS

Déodat Dolomieu, membre de l'Institut National (1750-1801); sa correspondance, sa vie aventureuse, sa captivité, ses œuvres. ALFRED LACROIX. Ouvrage publié par l'Académie des Sciences avec le concours de l'Institut (Fondations Debrousse et Gas) Paris, Librarie Académique, Perrin et Cie, 1921, 2 vols, lxxx, 255, and 322 pp., port., 8vo. With line portrait frontispiece.

THE latest work of Professor Alfred Lacroix is a very important contribution to the history of the scientific men of France in the eighteenth century, perhaps all the more so that the name of Dolomieu is not well known in foreign lands.

The book has grown out of the researches made by Professor Lacroix in preparing the biographical sketch of Dolomieu which he read before the Académie des Sciences on December 2, 1918, and which has already been reviewed in SCIENCE. He found a number of Dolomieu's letters in the library of the Muséum d'Histoire Naturelle, and traced out many others in foreign libraries and in private hands. The author remarks that the chief value of those letters he has selected for publication is that they include a series, covering a period of some twenty years, written by Dolomieu to a small number of particular friends, so that they enable the reader to follow his life day by day in its more intimate details. The earliest in date of these letters were addressed by Dolomieu to his patron, Duke Alexander de la Rochefoucauld, member of the Académie des Sciences and colonel of the regiment "De la Sarre," who was destined to be assassinated in 1792, almost in Dolomieu's arms.

An interesting group of 47 letters are those written to the Sicilian naturalist Giseni; these treat at length of the important investigations of Dolomieu in the domain of volcanic formations. Other groups of letters are those sent to

the Chevalier Philippe de Fay, the truest of Dolomieu's friends, to Picot de la Peyrouse, botanist and geologist of Toulouse, to the great geologist Saussure, to the Genevan physician Pictet, to Pierre Picot, professor of theology in Geneva, and to Frederic Munter, professor of theology in Copenhagen.

The following extract from a letter to this last named correspondent, is a characteristic example. Dolomieu, after passing safely through the throes of the French Revolution, was appointed, in 1796, lecturer in geology and the distribution of minerals at the newly-organized Ecole des Mines. A year later, Jan. 15, 1797, he writes to his friend Munter:[1]

"The sciences, which were for me formerly a relaxation, have become a profession which furnishes me the means of livelihood, and none the less I cultivate them with pleasure. I am chiefly occupied with mineralogy and geology, and I give lessons in these branches at the Ecole des Mines during the winter. During the summer I travel to inspect the mining operations. I have assumed charge of the mineralogical articles of the Dictionnaire Encyclopédique, and I write articles which are published in various journals. Thus I employ my time in a manner agreeable to myself and I advance without much disquietude toward that fatal term against which all human hopes make shipwreck. We have become so accustomed to the idea of death, that we now see our last hour approaching with complete indifference."

The biographical sketch already noted is reprinted by Professor Lacroix at the beginning of the first volume of the present work (pp. i—lxxx). To this succeeds the unique record written by Dolomieu in 1799, in his prison at Messina, where he was incarcerated because of his supposed guilt, as a Knight of Malta, in aiding Bonaparte to seize the island. It was inscribed on the margins of the leaves of a book he had succeeded in obtaining, and which is now a precious possession of the Muséum d'Histoire Naturelle (pp. 1-44). The quality of this record may be exemplified by the following brief extract:

"My passion for the phenomena of Nature was so strong that every year, when spring renewed the life of the vegetable kingdom and gave new force to all organized beings, the environs of Paris seemed too restricted for me, its atmosphere heavy and offensive . . . . Therefore each year I hastened to the mountains, and sought on their summits those profound emotions which the contemplation of very great objects always procures us . . . Now, confined within a space of twelve feet long, and ten feet in height and width, I can only contemplate my own wretchedness and reflect upon the vicissitudes of fortune and my strange destiny."

Fortunately the Italian victories of Bonaparte opened his prison doors, his liberty being prescribed in one of the articles of the peace treaty of Florence, March 20, 1801. However, his enfeebled health did not long permit him to enjoy his recovered freedom. He died at Chateauneuf, November 6, 1801, but fifty-one years old.

Of Dolomieu's scientific attainments, Professor Lacroix notes that it was principally in the study of volcanic phenomena that he left his trace, and asserts that by his researches concerning Auvergne, he takes his place in the first rank of those who have recognized and demonstrated the relations existing between volcanism and the internal heat of the earth.

GEORGE F. KUNZ

[1] Vol. II, p. 138.

SPECIAL ARTICLES

DISSOCIATION OF HYDROGEN IN A TUNGSTEN FURNACE AND LOW VOLTAGE ARCS IN THE MONATOMIC GAS

IN the course of an investigation of arcing characteristics of diatomic gases being carried on in this laboratory, it was found that the arc between a hot tungsten filament and a plate anode in hydrogen struck and broke at a minimum of 16.4 volts. This potential is about that ascribed by Bohr's theory to the potential necessary to accelerate an electron so that it will dissociate the molecule and ionize one of the atoms upon impact. In view of the fact that Bohr's theory puts the ionizing potential of the hydrogen atom at 13.52 volts

and the radiating potential at 10.14 volts, it seemed that it should be possible to maintain an arc at 13.52 volts or even as low as 10.14 volts. The failure to maintain an arc at these potentials was ascribed to the insufficient amount of monatomic hydrogen in the tube.

During the course of this investigation, Professor K. T. Compton suggested that it might be possible to dissociate hydrogen by means of a cylindrical tungsten furnace which could also be used as one of the electrodes for the arc. The writer undertook the investigation of the possibility of this and computed the per cent. of monatomic hydrogen which would be in equilibrium with the diatomic gas on the basis of Nernst's equation of the "reaction-isobar."[1]. Taking the heat of dissociation to be 84,000 calories per gram, $\beta = 0.000225$, and the chemical constants for the diatomic and the monatomic hydrogen to be[2] −3.4 and −1.6 respectively, the per cent. of monatomic hydrogen in equilibrium with diatomic hydrogen is indicated in the following table:

	1000°	1500°	2000°	2500°	3000°
Pressure	K	K	K	K	K
0.5 mm.	.005	2.36	61.5	Complete	
1.0 mm.	.004	1.69	40.0	98.8	
5.0 mm.	.002	0.74	26.7	90.4	Dissociation

As it is possible to obtain a temperature of more than 2000°K in a tungsten furnace, it seemed that a sufficient amount of monatomic hydrogen could be obtained to maintain the arc at the lower potentials.

The furnace consisted of a cylinder of thin sheet tungsten, furnished by the General Electric Company, mounted on water-cooled leads and heated by means of an electric current. A tungsten filament ran axially through the furnace and was also heated by a current. The fall of potential in the furnace and that in the filament were in the same direction and of nearly the same amount. A potential was applied between the furnace and the filament, and was tried in both directions. The potential of the arc was corrected to the amount between the middle of the two electrodes. Gas pressures of 0.6, 0.8 mm, 1 mm, and 2 mm were used.

When the furnace was not heated the arc could not be maintained below the 16.4 volt point. When the temperature of the furnace was raised, a point was reached at which the arc would strike at about 16.6 volts and break at about 14 volts, indicating that the increased dissociation in the arc raised the percentage of monatomic gas sufficiently so that the arc could be maintained to approximately the ionizing potential of the atom. At still higher furnace temperatures the arc could be made to strike and break at about 13.5 volts and the results when plotted showed also unmistakable evidences of ionization at about 10.3 volts. Curves were obtained showing three sharp breaks in the neighborhood of 10.3, 13.2, and 16.2 volts. With the furnace at a very high temperature the arc would strike at about 14 volts and break at 11 volts. It seems certain that the arc struck at the ionizing potential of the atom and was maintained as low as the resonance potential of the atom. There was a considerable amount of tungsten "sputtered" on the walls of the tube, and from this it was concluded that the temperature of the furnace must have been 2000° to 2500° K. The results seem to indicate that the percentages of dissociated hydrogen calculated above are approximately correct.

These results constitute, it is believed, the first direct experimental proof of the correctness of the values of the radiating and ionizing potentials predicted by Bohr's theory for the hydrogen atom, and of the interpretation of the ionizing potential of the molecule as due to its dissociation plus the ionization of one of the atoms.

A complete report of these experiments will be published later. The apparatus will also be used to study the arcs in other gases and for investigating the excitation of the spectra of substances at high temperatures.

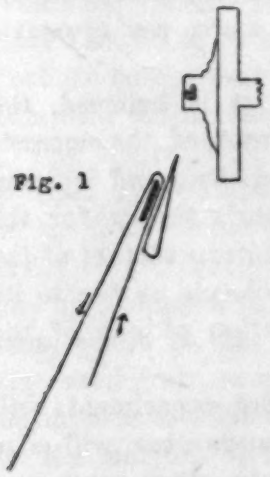
O. S. DUFFENBACK
PALMER PHYSICAL LABORATORY,
PRINCETON, NEW JERSEY,
JANUARY 26, 1922

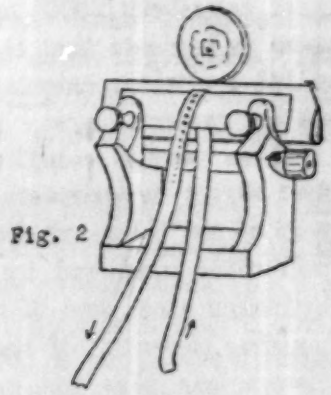
[1] Nernst: Theoretical Chemistry.

[2] Reiche: Ann. d Physik, 58, p. 657, 1919, and Shames: Phys. Zeits., 21, p. 41, 1920.

A SIMPLE METHOD OF DEALING WITH ELECTRIFIED MICROSECTIONS

ELECTRIFICATION of the sections is a frequent cause of trouble in microtomy. The sections when cut fly back into the paraffin block when the block rises for the next cut, or, if a short ribbon has already been cut, this flies to the knife, twists and curls, or "bunches up" on the knife in such a way that it is an exceedingly wearisome task to seriate the sections, and requires almost infinite care and patience. The causes of electrification may be various. It is owing either to atmospheric conditions or to faulty methods of infiltrating or blocking. The use of a metal drum on which the sections may be wound as cut, reduces somewhat, as is well known, the difficulty experienced because of the electrification of the sections. The suggestion of Guyer (p. 47 of his revised ed. of *Animal Micrology* 1917) to postpone cutting till a more favorable time is not very satisfactory to one who is compelled, because of press of time, to cut continuously. The following simple device I have used with electrified sections and have found very satisfactory. The labor of mounting such sections, by its use, has been very much reduced, and I believe it will be quite generally serviceable.





Figures 1 and 2 show the whole device, which is adapted to any of the common types of rotary microtomes for the cutting of serial sections. It consists of a thin blade of celluloid (one of the 6-inch rulers furnished by the biological supply-houses does very well). This is screwed flat against the section-knife by means of the usual knife-holding screws of the carriage. (Fig. 2). A long narrow strip of thin, tough paper is passed up between the celluloid blade and the microtome knife, until about 3 cm. of it protrudes above. After the paraffin block has been properly trimmed and adjusted to the knife, the sections are cut, and as each one is cut, it is attracted and held by the paper-strip which is pulled along with the fingers so as to produce a series. (Fig. 2). When the strip is nearly filled with sections, it is taken and fastened to the table or board with thumb-tacks, to keep it from curling, and another strip substituted.

By means of this extremely simple device, the writer has found it possible to cut with excellent seriation material which otherwise, owing to electrification, would have been impossible.

S. W. GEISER

ZOOLOGICAL LABORATORY,
THE JOHNS HOPKINS UNIVERSITY

THE AMERICAN CHEMICAL SOCIETY

(*Continued*)

DIVISION OF INDUSTRIAL AND ENGINEERING CHEMISTRY

H. D. BATCHELOR, *Chairman*
H. E. HOWE, *Secretary*

SYMPOSIUM ON FILTRATION

D. R. SPERRY, *Chairman*

Filter cloth and its relation to filtration: ALVIN ALLEN CAMPBELL. Filter cloth is a very important consideration. Principal kinds are made of cotton, wool, jute, hemp, nickel and monel metal. Cotton duck the most used, but being replaced by materials of longer life though not necessarily better filterers. Solids really are the filter medium, the cloth is merely the retaining wall. The combination of strength, fineness and rapidity is what is wanted. Life of cloths depends on chemical action tending to destroy its use. Considers monel metal the best cloth material in most cases. Gives interesting list of various acids and salts and whether or not monel metal is recommended. Warns against electrolytic action on monel cloths, citing potassium permanganate as a case in point. Gives opinion

as to round, square or rectangular openings. Wire cloth a failure in filtering certain colors. Filter aids work well with wire cloth. Does not recommend that wire cloth be rolled.

Filter aids: C. P. DERLETH. The term filter aid is defined and a list of materials used for this purpose given. Materials to which the term Kieselguhr is applied are discussed. Author divides filtration problems into three classes on the basis of whether the solids in the mixture are rigid, non-rigid or a combination of the two. A discussion is given as to the manner in which a filter-aid may be used and the advantages accruing therefrom, in each of the three cases. Desirable characteristics in filter-aids is given. Filter-aids are said to improve clarity of filtrate, reduce power consumption, reduce loss of liquid in cake, reduce labor in cleaning cloths, increase life of cloths, and increase rate of flow.

The feeding of filters: J. F. SPRINGER. Defines "feeding" as consisting of the transmission under pressure of the unfiltered liquor from a point where it is received from storage to the inlet aperture of the filter. Necessary equipment is pipe-line, pump and power. Suggests that in order to keep pump and valves clean from solids, precipitation of the solids when possible ought to be done either in filter or between pump and filter. Suggests possibility of solids being dissolved before reaching pump and then again precipitated between pump and filter. Describes feeding devices made of various materials and the corrosive action of certain substances thereon. Discusses suction, gravity and pressure feeding and appropriate apparatus. Steam, power-reciprocating, centrifugal pumps and montejus are dealt with.

Fundamental laws of filtration with suggestions regarding research work: D. R. SPERRY. The writer develops a formula which is a statement of the fundamental laws governing filtration. This is done to form a foundation upon which filtration may be put upon a scientific basis. Definitions of filtration, porous mass, filter-base and filter are given. Three indispensable conditions of filtration are difference in pressure between the two sides of the porous mass, a filter base and a filter. A study is made of the phenomena of filtration and it is found that the rate of flow of filtrate at any instant equals the rate of flow through the cake at that instant were there only liquid above the cake. With this as a basis a study is made separately of the laws of flow through cake and the laws of building up of cakes. The two expressions are combined into one which is the fundamental law of filtration as follows: $Q = \sqrt{WPT + N^2} - N$ (for constant pressure conditions); $Q = \frac{WP}{2M} - \frac{WRM}{2}$ (for constant discharge conditions); where Q = total discharge, P = pressure, T = time, R = resistance of cake, Rm = resistance of porous mass, c/o = per cent. of solids, M = constant discharge rate, K = rate of disposition, $W = \frac{2K}{R\%}$, $N = \frac{KRm}{R\%}$. Units for measuring K, the rate of deposition, and R, the resistance of cake, is given. A list of research suggestions follows.

Washing filter presses: EUSTACE A. ALLIOTT. Washing is used to recover a valuable liquor from the solid particles which retain it or to free such particles from impurities dissolved in the adhering liquor. Generally wash water ought to be as little diluted as possible; hence the smallest quantity should be used. Adsorption, capillary diffusion, formation of chemical compounds, and colloid formation on removal of electrolytes are disturbing factors in washing. Each of these factors is discussed. Simple washing involves too much space and care. For best washing results plate and frame type filters should be used with thorough washing. Air vents should be provided at top of wash chambers, wash must leave at top of press and enter at bottom. Considers various mechanical appliances for washing, hydrometer bowls, wash pumps, and montejus. Under ideal conditions wash equal to one displacement volume should effect complete washing. A number of washing results is given from actual practice, showing displacements volumes of 1.6 to 5.5. Describes stage washing. Gives a number of interesting wash curves, and cuts of mechanical appliances for washing.

Pulp or filtermasse filters: E. E. FINCH. Divides filters into two classes—those whose primary purpose is for clarification and those for retaining solids. The pulp filter belongs to the first class and uses cellulose as a filtering medium. Gives a short history of the pulp filter. Origin was probably in Germany. Gives a list of various substances used as a filter-masse with appropriate remarks. Concludes pure cotton masse the best. Describes method of preparing and using filter-masse. Pulp filters can be constructed for handling liquids which must not touch the ordinary metals. Discusses advantages of a clear product for manufacturer. Filtration in pulp

filters is a violent agitation which may cause precipitation requiring re-filtration. Gives methods of treating liquids by pasteurizing, chilling or settling. Mentions filtration of glue and gelatine.

Atkins-Shriver automatic filter press: H. D. ATKINS. This apparatus is a modified form of a round, center-feed filter press. A shaft passes through the center openings, on which is mounted plows, one in each chamber. The press is mounted on trunnions and is filled in the vertical position. When filled the shaft is rotated and the plow by moving in a spiral manner peels off the cake from the chambers. The cake pieces fall out of the press through the central openings. The plows do not remove all the cake but leave a thin layer on the cloths. If it is desired to remove this layer it may be sluiced off. For assembling and clothing the press is swung into the horizontal position. Washing may be done in the press. Claim is made that this press saves wear and tear on cloths, saves labor, washes thoroughly, and is well adapted to arrangements to carry away cake. This type of press costs more than the ordinary filter press per unit of filtering area.

Vallez rotary filter: H. A. VALLEZ. This apparatus consists of a cast-iron cylinder so made that by removing bolts it can be split lengthwise disclosing a hollow shaft on which is mounted the filter leaves. Filtrate from leaves is drawn away through center of shaft. When cylinder halves are bolted together the material to be filtered is pumped into the interior under pressure, causing filtrate to issue from shaft. Filter surfaces may be sluiced off. Extra shafts with leaves may be kept to facilitate repairs. Leaves are spaced 2½, 3 or 6 inches apart. A screw conveyor at bottom of cylinder removes the solids, which drop off the leaves when pressure is relieved or a back air pressure applied. Claim is made that the rotation of leaves while filtering causes even depth of solids, indicating uniform washing. Used in sugar factories.

Centrifugal filters: H. C. BECKMAN. There are two classes of centrifugal filters, those in which the drum is perforated and those in which the drum is imperforated. The first class is used largely in sugar factories. Experiments have been made in which filter paper or cloth is used over perforations. Has no advantage over ordinary pressure filter and several disadvantages. Centrifugals of the second class use filter paper and act in a measure as a self cleaning filter due to the fact that the solids are discharged from the discs by centrifugal force. Due to this fact small areas have large capacity. A disadvantage is the smallness of size. A ten-inch drum eight inches high with twenty seven-inch filter plates operating at 6,000 R.P.M. is the largest size found commercially practical. Costly liquids like physiological serums, expensive varnishes, etc., are handled by centrifugal filters. Maintenance and upkeep are nominal. Largest size requires about two H.P. and about four square feet floor space.

Modern leaf type filters: ROBERT C. CAMPBELL. Description is made of Kelly and Sweetland leaf filters. Operating instructions for complete cycle are given. Washing is effected by stopping formation of cake while there is yet space between adjacent leaves. Eighty-five to 125 per cent. of the weight of discharged cakes is required for complete washing. A disc filter of the continuous suction type in which discs are mounted on a rotating shaft which allows them to dip into the mixture to be filtered is described. Pressure disc filters are suitable for handling sludges. Containing from less than one per cent. of suspended solids to the highest per cent. of solids which can be conveniently pumped and drained from filter. By use of Kisselguhr colloidal or gummy solids may be handled. Suction disc filters are recommended for sludges containing over 10 per cent. of comparatively free filtering solids wherein a cake of greater than one fourth inch thickness may be built in from one to eight minutes. Average capacity of suction filters is from 300 to 700 pounds of dry solids per square foot filter area per 24-hour day. Data is given regarding size of air and sludge pumps for pressure or suction disc filters, also water required for sluicing. When suspended particles are soft and compressible the plate and frame filter will produce a drier cake than leaf filters. Claims leaf filters have lower cloth consumption than plate and frame filters.

Oliver continuous filters: H. A. MORRISON. (1) Types manufactured—being a brief description of the individual kinds made. (2) General principles involved—covering the use of the continuous vacuum filter. (3) Characteristics to be considered in filter applications. (4) Uses—with generalized statement of the more important fields of operation and special description of the unusual problems we have solved. (5) Installation and operating costs—showing complete installation and operating costs in detail. (6) Advantages—realized by use of continuous vacuum filters as compared with plate and frame presses

and other intermittent types. (7) Limitations and disadvantages.

Suction filtration: G. D. DICKEY. After a brief outline of the development of suction filtration, there are taken up the four main points of interest to filtration operators, viz.: Cake formation, washing, drying, and discharge. Under "Cake Formation," there is discussed the various factors which modify cake building in suction apparatus. Examples are cited as to capacities and rates of flow of specific materials under varying conditions, which will illustrate the influence that these conditions exert over the deposit of the filter cake. Following the discussion of the filter cake comes that of washing of the cake, which of course is dependent upon the formation of the cake itself, but which can be greatly aided or hindered by the filter operator. The discussion of cake drying and discharge is also based primarily upon the cake formation, but allows of many modifications before obtaining the desired results. Next there is given a brief description of the construction and operation of the open tank type of filter, the continuous rotary filter, and the continuous rotary hopper dewaterer, together with the advantages and disadvantages of each type. A number of lantern slides have been provided, so that the discussion of the construction and operation can be illustrated. In conclusion, there is given specific data as to the handling of a number of materials by the three types of apparatus above mentioned.

Industrial filter media: ARTHUR WRIGHT. Defines industrial filtration as the separation of a comparatively large amount of solids from small volumes of liquid, hence small rates of flow are permissible and filter cloths used as contrasted with the municipal filtration where gravel beds are used and conditions are the opposite. Selection of filter fabric depends upon whether for non-corrosive or corrosive liquors. For the latter, wool, metal, asbestos, stone, etc., is used, while for the former, cotton is used. Describes various weaves of cotton and its use. Fabric filtration should be of surface type, and not bed filtration where solids enter interior of the medium as in loose thick duck. Suggest superficial layer of thin muslin to prevent bed action, permitting cake to fall off easily. In certain kinds of filters the cloth porosity must be of definite kind to permit use of back pressure. Cake adheres more strongly to unnapped cloth. Discusses drainage provided under cloths. Precoating cloths should be used where initial filtrate must be clear. Shrinkage and stretch of cloth is considered. Mentions incrustation due to lowering pressure and suggests action to be taken.

The use of filter-cel for industrial filtration processes: G. M. HICKEY. Filter-Cel, a porous cellular product, is used as a filter aid, by mixing a small percentage with the liquor prior to filtration, overcoming slimes and giving brilliant filtrates. In cereal beverage filtration, addition of one fourth pound of Filter-Cel per barrel insures complete removal of yeast cells, gives brilliant product and permits use of modern pressure filters. In crude and refined vegetable oils it aids in the removal of foots, soaps and slimes, giving clearer filtrates that requires less bleach for refining. When mixed with the bleaching agent, it increases the capacity of filter and gives dryer cakes. Apple products and fruit juices are mechanically clarified by filtration with small quantities of Filter-Cel. Soap lyes and fats are clarified using one per cent of Filter-Cel, improving filtration and the quality of by-products. Catalytic agents from hydrogenation processes are completely removed by filtering with Filter-Cel.

Plate and frame filter presses: G. B. RICE. The filter press includes a large filter area in a small floor space, high pressure can be used, the apparatus is simple, unskilled labor only is required for operation, and repairs are quickly made. Considers the plate and frame type the best form of filter press. Describes washing and various combinations used in filter presses. Filter presses can be made of various materials, as iron, for ordinary materials, wood for weak acid liquors, lead for strong sulphuric acid. For wooden plates resinous woods are best, as yellow pine; such wood will stand 25 per cent. cold HCl. Hot solutions tend to destroy the resin, so for that purpose maple or oak is best. Describes operation and storage of wood presses. Discusses filter plate surfaces, closing gears, and filter cloths. For most aqueous solutions, cotton cloths are good, but for strong acid solutions asbestos, wool or camel's hair cloth is suitable. Wire cloths made of monel metal, copper, nickel and bronze can be used.

The filter press: D. R. SPERRY. The filter press is defined as a press employed for holding together the component parts of a filter. The component parts of the filter consist of plates or plates and frames. The filter press is described by aid of illustrations. Recessed and flush plate and frame operation is defined. Filter plates and frames may be made of various materials to suit the substance handled. This is also true of filter-

bases. A discussion of plate surfaces tends to show that correct design should be for long wear of cloth and proper drainage. Also that the contact area of the cloth does not reduce the net filtering area as might be supposed. The filter press comprises most filter area per unit of floor space, can employ high pressures, has low repair costs, produces the driest cake, is economical in clothing, can be operated by cheap labor and is the most universal and widely used filter apparatus to-day. Eleven plant installation views are given.

A symposium on the chemistry of gases and fuel was also held with C. H. Stone chairman and R. S. McBride secretary. The following four major subjects were discussed:

(*a*) *Coke-oven problems,* discussion to be opened by W. H. BLAUVELT, F. W. SPERR and others.

(*b*) *Low temperature carbonization of coal,* discussion to be opened by H. C. PORTER.

(*c*) *Gas works control,* discussion to be opened by E. C. UHLIG, J. R. CAMPBELL and O. A. MORHOUS.

(*d*) *Gas analysis and its applications,* discussion to be opened by G. W. JONES, E. R. WEAVER and A. H. WHITE.

Two new methods for determining light oil in coke oven gas: ARTHUR L. DAVIS. The most accurate and thoroughly reliable method that has been developed to the present time utilizes activated carbon as the absorbing medium. Absorption of the light oil is rapid and the carbon is very convenient to handle. The absorbed light oil is removed by distillation of the enriched carbon with cresol and the subsequent treatment of the distillate with caustic. The true light oil recovered, uncontaminated with wash oil, may be examined and its quality determined. A very satisfactory means of absorbing light oil is to pass the gas through a plate and bell tower, laboratory size, using cresol as the absorbing medium. A tower of this type is imperative since incomplete absorption will be obtained using other than this general type of equipment when any liquid absorbent is used. The cresol is stripped of the light oil and the distillate agitated with caustic. The light oil obtained is true light oil with no high boiling ends due to the lower boiling portions of wash oil being present.

Standardizing gas combustion by premixing portions of air with gas: N. H. GELLER.

A chemically controlled automobile: GEORGE G. BROWN, JR. The average motor car wastes twice as much energy as is converted into useful work. The thermal efficiency averages not over 15 per cent. This loss, entirely preventable, is a waste of a valuable and limited natural resource, petroleum. In all industrial combustion problems increased efficiency can be obtained by returning as much heat as possible from the exhaust gases to the combustion zone by preheating the air. Another factor, known as turbulence, which results from the velocity of the mixture entering the cylinder, has an equally noticeable effect upon the rate of combustion. Repeated tests have shown that 30, 35, 40 miles per gallon and even more may be obtained driving at constant speed along a level highway and burning a lean hot mixture. It has been found that the two variables, temperature of air and manifold suction, are sufficient in themselves to supply all the automatic control desired. Working along these lines a carbureter has been designed from a scientific and mathematical standpoint that can be made to deliver a mixture of any proportions desired under any conditions. It has been found possible to obtain 35 to 40 miles per gallon on a standard Ford touring car with equally quick acceleration and even more flexibility than could be obtained with standard equipment giving 20 miles per gallon under the same conditions.

Theoretical maximum temperature: GEORGE G. BROWN, JR. (1) A comparison of the values for specific heats of the products of combustion as obtained by the various investigators. (2) Calculation of maximum temperatures using a table of mean specific heats, or thermal capacities: *a.* Estimating temperatures and solving by trial and error; *b.* The graphical method of Damour. (3) Calculation of maximum temperature using the equations for thermal capacities: *a.* Algebraic solution; *b.* Slide rule solution; *c.* Graphical solution.

The formation of oxides of nitrogen in the slow combustion and explosion methods in gas analysis: G. W. JONES and W. L. PARKER. Procedure and results of investigation are given showing the amounts of oxides of nitrogen formed when gases are analyzed by the slow combustion and explosion method. The following conclusions were obtained: The production of oxides of nitrogen by the slow combustion method when the time of burning is not more than three minutes and the wire heated not greater than a bright yellow is within the experimental error in routine gas analysis. Under the above conditions not more than .003 c.c. of oxides of nitrogen

were produced by the explosion method when air was used as the oxygen supply. When mixtures of air and oxygen were used as the oxygen supply in the explosion method appreciable quantities of oxides of nitrogen were produced which are too large to be disregarded in gas analysis. The method used for determining the quantity of oxides of nitrogen produced was a modification of the di-phenol sulphonic acid method as used in water analysis.

The present status of methods used for fuel gas analysis: G. W. JONES. The constituents present and difficulties encountered in the accurate analysis of fuel gases are given. The methods used at the present time, considerations which must be taken into account in choosing a particular method, the comparative accuracy of the different methods and debatable points which require further consideration are discussed.

Electric heat for thermal processes: E. F. COLLINS.

Humidity equilibria of various common materials: ROBERT E. WILSON. A knowledge of the equilibrium amount of moisture held by various materials as a function of the relative humidity of the air is very important for a variety of purposes. The author presents determinations by a method previously described in the *Journal*, of the humidity equilibria of the following materials: cotton, linen, paper, jute, hemp, viscose silk, cellulose nitrate silk, cellulose acetate silk, rubber, leather, feathers, catgut, tobacco, crackers, bread, macaroni, etc.; and includes data gathered from various sources on other materials, such as wool, silk, paper half-stuffs, timber, flour, etc.

The frictional resistance to the flow of viscous liquids through elbows: ROBERT E. WILSON, WILLIAM H. MCADAMS and M. SELTZER. The frictional resistance to the flow of liquids through elbows has been the subject of a considerable number of scattered experiments, but the results are seldom expressed on any uniform basis and in many cases the methods of measurement were faulty. Furthermore, there is practically no data on the frictional resistance to flow through elbows for very heavy oils flowing in straight line motion. The authors present a series of data covering the whole range, from highly viscous oils to water, and show that, while the customary rule of assuming an elbow to be equivalent to thirty or forty pipe diameters' length of straight pipe holds very well over the whole region of turbulent flow, the resulting correction is far too high in the region of viscous flow, dropping to as low as two or three diameters for very viscous liquids in small pipes.

A fermentation process for the production of acetone, alcohol and volatile acids from corn cobs: W. H. PETERSON and E. B. FRED. Corn cobs are a possible raw material for the production of acetone, ethyl alcohol, formic acid and acetic acid. These products are obtained by fermenting a sirup which is made from corn cobs by hydrolysis with dilute sulfuric acid and contains chiefly xylose. This crude xylose sirup is fermented by *Bacillus acetoethylicum* under the proper conditions of nitrogen, and phosphate supply and hydrogen ion reaction. A continuous fermentation is maintained by filling the container with cinders to which the bacteria may attach themselves. The fermented solution is removed and a new sugar solution added without disturbing the bacteria. Under these conditions the fermentation is rapid and vigorous. The yield of products is 2.7 lbs. of acetone, 6.8 lbs. of alcohol and 3.4 lbs. of acid per 100 lbs. of corn cobs.

A new method of preparing sulphuric acid: P. C. HAESELER. Instead of oxidizing SO_2 with the oxide of nitrogen, selenium dioxide is used according to the equation: $2SO_2 + H_2O + H_2SeO_3 = 2H_2SO_4 + Se$. The selenium is filtered and reoxidized. A 50 per cent sulphuric acid free of selenium can thus be obtained without pressure. Anode slimes and other impure selenium sources can be used for the source of selenium, as roasting the same will yield an oxide sufficiently pure for the above reaction.

Corrosion under oil films and the protective action of certain colloidal solutions: WILBERT J. HUFF. An investigation by the writer in the research laboratories of the Bureau of Mines on the subject of corrosion beneath oil films caused by water soluble salts from perspiration residues, sea sprays, and certain manufacturing operations. Preliminary treatment with water, followed by a suitable emulsion, and finally by oil is recommended for inaccessible surfaces. Experiments are given to show the valuable anti-corrosive property of certain soap emulsions, and some of the conditions under which this protective property fails. The mechanism of the corrosion and protection is discussed briefly.

On the dehydration of tar and other organic emulsions: WILBERT J. HUFF. A note discussing some of the methods for the dehydration of tar and similar emulsions, pointing out a few advantages and disadvantages of each, together with a description of a method suggested by the